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Computer and communication technology is changing at an increased rate. New technologies are emerging; the price-performance of current technology is improving. There is a need to assess the impact of technology on new information systems projects particularly those dealing with distributed processing and electronic office systems. Such an assessment provides direction and guidance in long range and intermediate term information services planning. It can potentially prevent costly conversion efforts.

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Assessment of Technology for Information Services Planning*

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Abstract

Computer and communication technology is changing at an increased rate. New technologies are emerging; the price-performance of current technology is improving. There is a need to assess the impact of technology on new information systems projects particularly those dealing with distributed processing and electronic office systems. Such an assessment provides direction and guidance in long range and intermediate term information services planning. It can potentially prevent costly conversion efforts. An approach is developed for obtaining this assessment. Two case examples of applications are also provided which illustrate the method, results, and benefits.

1. Introduction

Technology in information services is changing at a more rapid pace now than in the decade 1965-75. Information Services here includes data processing, word/text processing and electronic office automation, information systems, data communications, and data administration. Several excellent books and articles have appeared which point to the nature of the change and its pace. Lecht [8] provides an overall view of various hardware, software, and communication developments. Champine [4] has more recently provided a fairly complete overview of technology. Recent assessments in communications and networks appeared in the IBM Systems Journal (see Branscomb [2], Frazer [6]). In addition technology change is a major focus of attention for consulting/planning companies such as A.D. Little, INPUT, Diebold and Associates, IDC, MSV, Dataquest, and POSPP. Their reports, available to subscribing organizations, highlight technology areas as well as specific devices and equipment. Trade magazines such as Datamation, Computer World, Electronic News, Computer Decisions, and Mini-micro Systems also provide additional information on new announcements.

These sources provide trend and forecast information for individual devices as well as industry segments. The technology assessment uses these types of sources and develops impact statements on how the technology is likely to affect the business or application system environment. The horizon may be as short as two-three years or as long as ten years. Other inputs to the assessment include an understanding of the organization's functional objectives as well as the environment of the current and future application system environment. The output of technological assessment is used in planning for individual projects as well as long range information systems planning. It defines constraints on what

is possible and supports objectives and strategy. Such a framework appears in Lientz and Chen [9].

The references listed above, although portraying how and when technology is changing, do not provide a mechanism for applying this information to the planning process for new projects. For example, finding out trends in the price of semiconductors or the development of bubble memories does not easily translate into management and application implications. This is not to say that these services are not needed. Rather it points to a need to translate the technology statements and findings into impact analysis on application systems and user organizations.

The need for assessing the available and potential technology has been pointed out in the literature on Information systems planning. Some include Steiner [16], Jantsch [7], Bright [3], Ayres [1], and McLean and Soden [14]. In most of these references the emphasis is on forecasting as opposed to impact assessment. Lientz and Chen [9] present a long range information services planning approach where the assessment feeds directly into the long range plan.

Having briefly discussed some of the literature and sources we can probe the reasons for making the assessment. In the past, most systems did not relate to any such assessment. One reason for this is that most such systems were batch processing oriented. They were less sensitive to improvements in technology since the manufacturer ensured that these applications could be migrated across to new equipment with relative ease. They were, for the most part, technologically transparent so to speak.

The above stability has not been the case with on-line and distributed systems. Some need technology advances to be cost-justified. Others are highly sensitive to changes in system software, hardware, and communications. There are obvious reasons for this. The technology is much more complex. Multiple technologies are involved (see Martin [15] and Enslow [5]). Distributed applications touch user organizations more directly. As such, they require compactness, reliability, and performance that are different from traditional systems. For example an application may need plasma displays for compact terminal size, bubble memories for editing or communications support, and high speed full duplex communications. Thus, a major reason for the assessment is to determine whether or not the technology will be available when needed.

A second reason is to coordinate the use of multiple technologies for application within large organizations. Technology does not advance evenly across all areas. Currently semiconductor technology is probably the major advance. Communication breakthroughs are dampened by government regulation on competition, bandwidth allocation, and intrastate communications. This means that communication lags. Examples are the availability of the offerings of Satellite Business Systems and AT&T's Advanced Communication Service (ACS). The assessment of technology must take this uneven development into account to facilitate planning.

What happens if no assessment is performed? Obviously in only a few cases will there be major crises because faulty assumptions were made on technology. In most cases it means applications fall back on more expensive, less efficient alternatives. This not only affects the cost benefit analysis, but may impact the ultimate acceptance of the systems by users.

Another possible outcome is that the application does not use the new technology, thereby increasing maintenance and enhancement. Lientz et al [13] and Lientz and Swanson [10], [11], [12] analysis the dynamics and behavior of application software maintenance. A major category of maintenance is that of adaptive maintenance where changes are made to a system so that it continues to meet its application environment. One set of changes is the user requirements for additional system features made possible by new technology. A technology assessment can assist in anticipating change and thereby potentially improve the planning and control of maintenance.

We have briefly discussed the need for technology assessment and what sources are available for the trend and forecasting of technology. Section 2 presents an approach to developing the assessment. Two applications are discussed in Section 3.

2. Formulation of the Assessment

The approach to the technology assessment here is based on the following general steps:

1. Define framework for the business-organization environment
2. Analyze technology trends and forecasts
3. Perform impact assessment using Steps 1 and 2
4. Test and refine impact assessment on specific application areas

Although most of our attention will focus on Step 3 it is necessary to define in more detail the other steps.

o Organization framework

Broadly this means a definition of not only what the organization does and wants to do in terms of information services, but also it includes the current information services environment. Included here are:

- new applications and areas the organization foresees
- the resources likely to be available over the assessment time horizon
- current data processing and office automation hardware, software, and communications
- application systems in maintenance and undergoing development
- anticipated external factors - government regulations, competition, etc.

This need not be documented formally. Nor must it be complete. A complete, accurate document is a long range plan. Although the previous long range plans can be a source of information, the objective is a sense of what will be needed from technology to support the organization.

- Technology trends and forecasts

The forecasting literature is vast and in some cases contradictory. This is not surprising since it may reflect subjective judgements on the availability of new technology. The need in this review is to be complete in covering major technology areas as well as to be selective in picking among different forecasts. An example list of technology areas is given in figure 1. Note that it is not meant to be complete or inclusive, but to provide an example. It includes technology areas as well as major characteristics for assessment. Not mentioned, since they apply throughout, are price and timing.

Figure 1: Technology Areas

A. Hardware

1. Memory - size, speed

2. Processor - size, speed

3. Terminals - size, speed, intelligence (function), reliability

   a. point of sale
   b. hard copy terminals
   c. CRT, plasma based
   d. remote job entry/remote batch terminal
   e. low speed printers
   f. intelligent terminals
   g. graphic terminals

4. Printers/graphics - speed, reliability/maintenance, functions

   a. traditional - impact type
   b. laser - high speed type
   c. plotting devices

5. Auxiliary memory - transfer rate, capability, access time

   a. magnetic disk
   b. magnetic tape
   c. bubble
   d. change coupled devices
   e. laser
   f. data cell-type/mass storage devices
   g. diskette

6. Input/output devices - speed, function, error rate, ease of use

7. Minicomputer/microcomputers

   (details as in 1-5 above)

B. System Software

1. Operating system - function, overhead

   a. timesharing

b. batch
c. on-line production

2. Data base management systems

a. batch
b. on-line inquiry/update
c. development aids

3. Languages/development tools

a. language enhancements
b. documentation aids
c. design/analysis aids
d. automated testing/data generator tools

C. Communications

1. Equipment - error rate, number/type of devices served

a. modems
b. multiplexors
c. concentrators

2. Transmission - capacity, availability, support

a. satellite
b. fiber optics
c. common carrier tariffs/regulatory setting (revisions of Communications Act of 1934).

3. Protocols and control

a. status of offerings - SNA (SDLC), X.25, etc.
b. new offerings, enhancements

4. Value added networks (VAN's)

5. AT&T - ACS

D. Application software

1. Packages offered using new technology
2. Vendor viability
3. Life cycle costs
4. Flexibility/adaptability

o Impact assessment at the project level

With the first two steps information is available on what technology is being used as well as where the technology is going. In addition enough is known of business plans and current/developing systems that an assessment is now possible. We will consider the assessment at two levels - project and organization levels.

At the project level the setting is detailed enough to permit consideration of specific equipment, software, and services. The application must be analyzed to determine the critical events needed to make system viable. Such events may fall in one of the following categories:

- technology is not yet available
- technologies available are not compatible and/or complete
- technology is here but is not yet at a cost-effective level for the application

An example of the first case is a relational data base management system. Lack of this may lead to expensive, inefficient alternatives (e.g., redundant, differently organized data bases).

Having technologies which do not yet mesh or are not complete may provoke expensive internall developed, tailored research efforts to fill a gap. This effort may later be scrapped when the gap is filled. The application system may need to be rebuilt later as a consequence.

Technology, which is available but is not widely used or inexpensive enough, may defer a project on economic grounds or force an expensive alternative to be undertaken. Examples here are devices which are not mass produced in quantities sufficient for low prices. Similar remarks hold for special purpose devices for which there is insufficient demand or for which there is a lack of competition.

Of course a project may even experience multiple bottlenecks. The assessment aims at quantifying when and how the technology will impact the application. From this an overall strategy can be developed for dealing with the shortage.

It can also happen that the impact is unexpectedly positive or neutral. Lower costs and/or improved performances can increase the number of users and /or usage. An example might be cheaper memory or terminal costs. The case where technology change has little or no effect on the application is interesting. On the surface it might appear that this could not happen since an area of major improvement continues to be the computer itself. However, this may be the case with old, badly maintained, inefficient application software. The software and its system software may have been frozen. Adding new hardware capability has little effect since the application may need emulation routines (e.g., an Autocoder application on 303X equipment replacing 360 equipment).

Of course more than hardware, software, and communications are involved. Personnel and suppliers are also involved. In order to minimize risk and insure completeness questions such as the following must be addressed:

personnel - technical:

- What skills will be needed to select/evaluate/use the technology? How will these skills be obtained (training, hiring, or?)? When will the skills be needed? How fast will they become obsolete?

personnel - user:

- What skills will be needed in user organizations for data collection/editing/analysis/output distribution/reporting? What training is needed? How will the staff composition change?

organization:

- Are the present approach/policies/procedures adequate to absorb and manage the technology? What liaison is needed between users and systems groups?

suppliers:

- What is the impact of technology on the vendors and suppliers that are likely to be used? What is the impact on product mix and obsolescence? How will the direction of the suppliers change? What is the likely effect of competition?

The output of the assessment whether favorable, neutral or unfavorable consists at least of the following:

- which technologies impact the application
- how each technology effects the application in terms of:
  - schedule and timing

cost

performance

functions/features

benefits to the user

maintenance and life cycle costs

reliability/security/integrity

cases of upgrade and enhancement

sensitivity/risk of technology availability or advancement to the application system

effect of technology on personnel (system, user), organization and suppliers

It is helpful if this is expanded to include a strategy for the project plan in dealing with the assessment. The assessment findings may lead to tasks which call for evaluation and implementing techniques as well as equipment or software.

- Impact assessment at the organization level

Obviously the impact assessment grows at the organization level. The areas of relevant technology grows. The user community expands. The assessment becomes more general. It also changes and requires added structure.

At the project level the technologies are more easily identified. With a large corporation or agency the technologies involved cannot be known

exactly. Geographic boundaries potentially expand. A general approach at the organization level consists of the following steps:

A. Determine specific technology devices and products that are likely to impact the organization's systems indirectly
B. Translate the effects of these advances on hardware, software, communications, personnel and organization, and suppliers and external services.
C. Assess the impact of technology by relating the results of the previous steps to classes of systems.

These steps do not replace the development of analyzing technology trends and forecasts. That analysis is general and not related to the particular organization.

In Step A some specific technologies might be microelectronics, image processing, fiber optics, computer storage devices, and point of sale technology. These, in turn with the analysis of the business and other technology, permit the estimation of effects on resources - hardware, software, etc. The benefits of a breakthrough may be diffused and not fully realized in this packaging (Step B). With the resource impact understood this impact on application classes can be developed (Step C). What application classes might be appropriate? Here is a partial list:

- batch processing production systems
- point of sale systems
- timesharing program development and testing

- o on-line systems being developed and in production
- o personnel computing
- o office automation applications
- o distributed data processing applications

At this point we would generally know how technology would impact classes of applications. The technology assessment could be written up in report form or it could be persued to apply it to specific projects.

- o Application to specific users or systems - long range planning

With a single application the assessment is likely to involve the project team working with the application. Then the impact is more straightforward and has been discussed. To apply an organization level technology assessment the goals of the project need to be reviewed. The assessment is intended to provide guidance to the project team in the near term. But it is also used to develop the long range information services plan and project slate. In the context of Lientz and Chen [9] a slate of potential projects emerges from current systems being developed and maintained, projects on backlog, emergency-high priority work, and projects arising from the long range plan itself. The assessment can be applied to systems in all categories with the exception of the non-predictable, emergency-high priority type. By understanding the feasibility and availability of technology projects can be eliminated, deferred, kept active or initiated. The technology assessment serves as a constraint in a management science framework here.

o Other applications

Doing a technology assessment inevitably brings up issues in technology and impacts which must be addressed technically and managerially. Such issues provide useful guidance for further work and provide specific local points for management. Some examples of issues include:

- impact of hardware acquisition plans
- shortage of qualified systems staff
- communications strategy using ACS/SNA, etc. in the future
- scarcity of application software packages
- residual value decline and accounting/financial practices

3. Applications and Remarks

We have seen what a technology assessment is and how it is developed. Attention can be directed to two case applications - one at an organization level, the other at a project level.

- Organization level technology assessment

Company A is a large, international energy related corporation. A is structured into a multiple number of semiautonomous units. Each unit has an information services group(s). The corporate based group provides information and planning coordination to the units. The technology assessment here is an organization assessment which does not fit a particular project, but which must be applicable across a range of company units. The company uses mainly IBM equipment and the assessment prepared in 1979 addressed the new IBM announcements (e.g., 43XX, 8100, 3730) as well as other technology areas. The sources used included those listed in Section 2. The assessment was composed of a management summary and technical detail. The technical assessment was divided into two areas: technology advances and technological impacts.

The advances in technology that were relevant to the units were: microelectronics, computer storage devices, communication satellites, and fiber optics. In each case price-performance trends as well as functions were given along with a brief discussion of application in hardware, software, and communications products. This is essential to provide an understanding of the effect of the advance on equipment and services provided to the organization.

The technological impacts were composed of two parts: one dealing with resources and the other dealing with specific information services trends affecting the company. The resource areas which should be common to almost all assessments includes hardware and system software, communications, applications software and data management, personnel and organization, and external services (external timesharing and turnkey computer systems). Areas of impact are specific to the organization. The three considered here were distributed data processing, electronic office automation, and microprocessor applications. Specific topics in resource and impact areas are given in figure 2.

Figure 2: Topics in a Technology Assessment Example

- resources
  - o hardware, system software
    - price performance of past/current/future systems
    - projected residual value/economic impact
    - IBM's industry position/43XX vs 8100/H series/System 38/operating systems
  - o communications
    - regulatory changes
    - emergence/establishment of new services (e.g., AT&T's, ACS)
    - scenario of mixed SNA and public network
  - o application software, data management
    - software packages
    - availability of relational/distributed data base management systems
    - automated system development aids
  - o personnel, organization
    - obsolescence, training problems
    - productivity
    - user organization involvement
  - o external services
    - use of timesharing vendors, changing services
    - turnkey systems - potential and problems

- impacts and trends
  - o distributed data processing
    - technology needed
    - issues of control/coordination
  - o office automation
    - alternative definitions
    - user requirements
    - availability forecasting of products
  - o microprocessor application
    - scientific/engineering applications
    - business applications

After distribution of the assessment an analysis was made of its impact. The effect was significant enough to be updated on an annual basis. Several research projects were initiated based on issues raised in the assessment. Projects in office automation were reoriented to adjust to the likely dates of technology availability. A residual value impact study was performed resulting in modified accounting procedures. Two projects that were to use aging data base management systems were redirected to data communications software.

- Project level technology assessment

Company B is a large national bank with its major activities in retail banking. A project was initiated to determine a strategy for automating and improving service in the area of personal lending. Personal lending here includes credit cards, automobile loans, personal and real estate loans, and leasing. Service improvements would aim at expediting credit review, payment processing, management reporting, and collections for delinquent accounts. The business plan envisioned a network of minibranches supported by computer and communications technology.

The assessment here had to address the timing and organization of the technology. Technology advances included microelectronics, computer storage devices, and local telephone - data communication service. These advances in turn were translated into impacts on point of sale terminals, communications multiplexors, terminal control units, and cost-performance analysis.

In the resource areas the focal points were:

- hardware, system software
  - o point of sale terminals
  - o data communications monitors
  - o mass, on-line storage

- communications
  - o intrastate regulatory policies
  - o transmission and control price/performance
  - o communications equipment

- application software, data management
  - o availability of relational data base management system
  - o personal, end user oriented software

- personnel, organization
  - o banking organization
  - o training, skills, job descriptions

- external services
  - o quality, availability of consulting services
  - o availability of timesharing links to credit corporations

The assessment was employed to establish a project plan and schedule. The payment processing and collection processes are being improved first. These depend on more traditional technology. Point of sale terminals and distributed systems are not cost-effective as yet on such a wide scale. However, a pilot test project is being initiated to test the marketing concept and to determine the cost-effective price of equipment for statewide installation.

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